STUDIES ON THE QUANTITY OF RADIATION REACHING THE GONADAL AREAS DURING DERMATOLOGIC X-RAY THERAPY

III. Shielding Technics and Other Precautions for Reducing the Gonad Dose*

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The greater use of various forms of ionizing radiation for medical as well as non-medical purposes is causing a rising concern over the possible undesirable effects of these invisible forces on the present population and upon future generations. This increasing concern has prompted increasing numbers of questions from physicians, physicists, and more recently, lay persons, concerning the upper limits in the amount of ionizing radiation, including that used for medical purposes, to which the general public may be exposed with relative safety. As a corollary to these questions the question now arises whether adequate measures are being taken to reduce the present radiation dose, in particular that reaching the gonads, to the lowest possible level.

The radiation received by the general population as a result of medical uses of ionizing radiation may be considered to come from the following sources: (1) Diagnostic x-ray; (2) therapeutic x-ray and radium; and (3) radioactive isotopes used both diagnostically and therapeutically. The amount of ionizing radiation from these sources reaching the gonadal area of patients has been either measured or estimated for most of the procedures in which they are used, (1–3). With the exception of Callaway, et al. (4), and our own studies (5, 6) we know of no systematic direct measurements made of the doses reaching the gonadal area of patients during routine dermatologic x-ray therapy. Our studies to date have shown that the gonad dose from such radiation, carefully administered under varying conditions, is usually small (7). It may, however, under certain circumstances approach or even exceed the limits of the basic permissible weekly doses allowed individual persons, according to the recommendations of the responsible national and international committees (8–10).

Our previous publications report on the gonad dose of patients receiving routine dermatologic therapeutic x-ray (5–7) and on special studies carried out on patients and a pressed wood phantom (7). The present paper, the third in the series, deals with studies performed with a phantom designed to investigate some of the sources and some of the characteristics of the radiation which may reach the gonadal area during therapeutic dermatologic radiation, as well as the relative effectiveness of various shielding technics designed to reduce this gonad dose wherever possible.

The phantom used for these studies was designed to simulate a patient being treated in one of two positions, lying horizontally on the x-ray table, or seated by the side of the table. In each instance the phantom occupied a similar position (by careful measurement) to that occupied by patients undergoing treatment with the same x-ray apparatus, table, and chair.

EQUIPMENT

Keleket K-112 pocket dosimeters with a recording range from 0 to 200 milliroentgens (mr) were used to measure the amount of radiation reaching the gonadal area.

The pressed wood phantom was constructed to conform to the average measurements and the general contours of a human body. Untempered pressed wood was used because of its comparable density to biologic tissues. The dosimeters were placed in the phantom in positions comparable to the location of the testes and ovaries in men and women respectively. For recordings at the testicular area, the dosimeters were placed between the 'legs' of the phantom, and for ovarian recordings they were slipped into closely fitting holes in the

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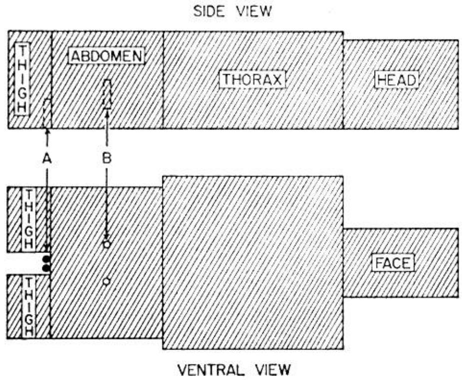


FIG. 1. Diagram of the pressed wood phantom used in these studies. Recording dosimeters were placed at A to measure 'testicular' doses of radiation, and at B to measure 'ovarian' doses.

'abdomen' of the phantom (Fig. 1). This technic has been demonstrated to give readings satisfactorily close to those actually recorded by dosimeters placed on the skin as closely as possible to the gonadal areas of patients during routine therapeutic procedures (7).

The x-ray machines used were Picker Zephyr 120 'Oilflow' models. The x-ray apparatus, table, and chair were the same for all studies, except where otherwise stated. Details concerning the dosimeters, the phantom, and the x-ray machines have been given in our previous publications (5–7).

The square sandbag used in these studies measured 11 inches on a side and 3 ½ inches through its thickest part; it weighed 16 pounds.

Shielding consisted of lead sheets 0.020 inches (0.5 mm) thick, and lead-rubber 0.06 inches thick (1.75 pounds per square foot). The lead-rubber, in the form of a sheet 24 inches wide by 56 inches long, was placed beneath the phantom at the 'hip' level, its long axis at right angles to the long axis of the phantom. The ends extending over the sides of the table were then brought up and overlapped on the 'abdomen' to enclose the 'pelvic' and 'abdominal' areas in a "wrap-around" *girdle* of lead-rubber sheeting (Table I, Fig. C).

PROCEDURE

Studies on the Phantom in a Horizontal Position

The phantom was placed on the table in such a way that it simulated the body of a patient lying horizontally. It was then "treated" with a series of x-ray exposures to the 'head,' 'thorax,' and 'abdomen,' each delivered according to standard technics, and of a quality and quantity comparable to those used in routine dermatological therapeutic procedures. The target skin distance was kept constant at 10 inches for these studies in the horizontal position; the effective field of radiation was 10 inches in diameter. A dose of 170 r of unfiltered radiation at 90 kv and 7 ma, with a half value layer of 0.8 mm Al was delivered in 58 seconds, except where otherwise stated. For each exposure, the dosimeter readings (representing the gonad dose or G.D.) as well as the distance from the x-ray tube head to the dosimeters, were carefully recorded. The first recordings were taken on the unshielded phantom following which three different methods of shielding the gonadal area were used in an attempt to reduce the gonad dose.

1. Efficacy of Shielding Materials:

With radiation delivered at 90 kv with an HVL of 0.8 mm Al, 0.5 mm of lead shielding allowed only 0.7% of the incident beam to pass through. With the same quality radiation, the *lead-rubber sheet* transmitted only 0.4% of the incident beam.

A. Shielding Covering Phantom: The amount of radiation leaking through the tube head, and the peripheral portions of the primary beam that could reach the gonadal area of the phantom was substantially reduced by covering all of the surface of the phantom, except for the 10 inch field irradiated (Table I, Fig. A), with a lead shield 0.5 mm thick. A series of exposures was delivered along the midline of the anterior aspect of the phantom starting at the 'head' and extending down to the 'abdomen.' The distance from the tube head to the dosimeters was carefully recorded for each exposure. The results are recorded in Table I. This method of shielding reduced the gonad dose to an average of 64% of the gonad dose recorded in the unshielded phantom.

B. Shielding Beneath the Phantom: The lead shield was placed beneath the full length of the phantom (between it and the padded table top) for the purpose of reducing any secondary radiation that might arise from the table top and structures beneath the table. This was done with the full realization that backscatter from the lead might add to the gonad dose (Table I, Fig. B). It will be seen in Table I that this method of

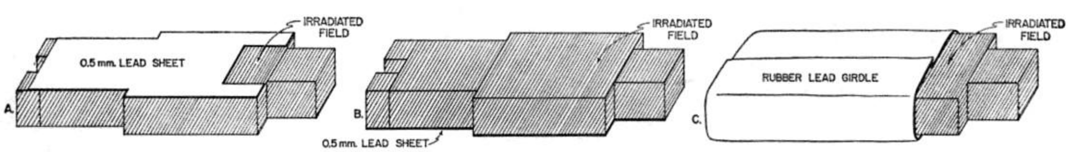
TABLE I

Studies on the Phantom in a Horizontal Position

Readings of the dosimeters placed in the testicular and ovarian areas of the phantom.* Comparison of the Gonad-Dose in the unshielded phantom with readings taken with (A) lead shielding surrounding the radiated field, (B) lead shielding placed beneath the entire phantom, and (C) a lead rubber girdle enclosing the lower two-thirds of the phantom.

Distances From The X-Ray Tube Head to Dosimeters	Dosimeter Readings in mr per Exposure			
	Unshielded phantom	A Lead sheet around radiated field over phantom	B Lead sheet under entire phantom	C Lead rubber girdle around phantom
inches				
36	<2	<2	<2	<2
32	4	<2	<2	<2
30	5	3	<2	<2
29	6	3	<2	<2
28	8	7	5	<2
27	8	8	5	4
26	9	8	7	6
25	19	11	12	7
24	25	20	22	15
23	40	27	30	24
22	80	54	73	43
21.5	145	96	102	49
21	185	127	141	58
20	>200	>200		
% of the Gonad-Dose in the unshielded phantom	100%	50–100% (64% Avg.)	62–90% (76% Avg.)	31–66% (49% Avg.)

* Readings at the testicular and ovarian areas were averaged for similar tube head to dosimeter distances. This was done for all studies in the horizontal position.



shielding reduced the gonad dose to an average of 76% of the dose recorded in the unshielded phantom.

C. Shielding Around Phantom—Lead-Rubber Girdle: This technic consisted of wrapping the lower two-thirds of the phantom in the lead-rubber girdle (Table I, Fig. C). It proved to be the most effective of the three methods used to shield the gonadal area, and reduced the gonad dose to an average of 49% of the dose recorded in the unshielded phantom. The amount recorded here must be due in some part to secondary radiation within the phantom and in some part to scatter.

2. Radiation of Softer Quality:

The gonadal area dose was measured again in the unshielded phantom, this time with the use of lower kilovoltage radiation (52 kv, 7 ma, HVL 0.6 mm Al) delivering 170 r per exposure to the same fields as before. The results are shown in Table II. This technic reduced the gonad dose to an average of 20% of the dose recorded in the

TABLE II

Studies on the Phantom in a Horizontal Position

Readings of the dosimeters placed in the testicular and ovarian areas of the phantom. Comparison of the Gonad-Dose in the unshielded phantom "treated" with 90 kilovolt radiation (HVL 0.9 mm Al) and with 52 kilovolt radiation (HVL 0.6 mm Al).

Distances from the X-Ray Tube Head to Dosimeters	Dosimeter Readings in mr per Exposure	
	90 kv radiation (HVL 0.9 mm Al)	52 kv radiation (HVL 0.6 m Al)
inches		
36	<2	<2
32	4	<2
30	5	<2
29	6	<2
28	8	<2
27	8	<2
26	9	<2
25	19	<2
24	25	5
23	40	7
22	80	19
21.5	145	24
21	186	43
20	>200	141
% of the Gonad-Dose produced by 90 kv radiation	100%	17–24% (20% Avg.)

unshielded phantom irradiated at 90 kv, 7 ma, HVL 0.8 mm Al.

The Phantom in a Seated Position

The 'thighs' and 'abdomen' of the phantom were placed in the chair alongside the table with the dosimeters located so that they approximated the gonads of a seated patient (Fig. 2). The position of the chair in relation to the x-ray table and thus the primary x-ray beam was changed by 2 or 3 inch increments through a range of positions occupied by seated patients having hands, wrists, or forearms treated on the adjacent table. The x-ray beam was directed vertically at a measured, fixed area on the flat table surface.

The amount of radiation reaching the 'testicular' and 'ovarian' areas was first determined on the unshielded phantom over the above mentioned range of distances between dosimeters and x-ray beam (Table III). Several methods of shielding were then tried, each designed to reduce the gonadal area dose to the lowest possible level without affecting the therapeutic efficacy of the primary beam:

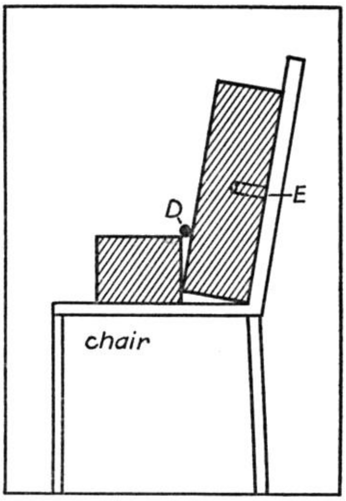


FIG. 2. 'Abdomen' and 'thighs' of the phantom as used to simulate a patient in a seated position. Dosimeters at D and E represent the testicular and ovarian areas, respectively.

1. Restriction of the size of the field of radiation. Lead shields 0.5 mm thick were placed on the x-ray table to form a 4 inch square, the center of which was at the axis of the vertical x-ray beam. (A 4 inch square was chosen as representative of the average sized area of dermatitis irradiated on hand or forearm.) With this technic the gonad dose was reduced to an average of 23% of the dose recorded when there was no shielding. The amount of radiation reaching the 'ovarian' area was reduced somewhat more by this procedure than that reaching the 'testicular' area (Table III).

2. The sandbag placed in the field of radiation. The sandbag was placed in the center of the irradiated field just as it is used to support that part of the extremity being treated in clinical practice. As the sandbag measured 11 inches square it filled the entire field of effective radiation. With the sandbag in position, the gonad dose was reduced to an average of 62% of the dose recorded when the field was irradiated without a sandbag (Table IV). When the irradiated field was reduced to an area 4 inches square by peripheral lead shielding then the addition of the sandbag made little difference in the gonad dose (Table IV).

TABLE III

Studies on the Phantom in a 'Seated' Position

Readings of dosimeters placed in the 'lap' (testicular) and the ovarian areas. Comparison of Gonad-Dose with an unshielded field and with restriction of the field of radiation to a 4 inch square on the x-ray table.

Distance From Axis Of X-Ray Beam To Dosimeters In Lap	Dosimeter Readings in mr per Exposure			
	Unrestricted (unshielded) field of radiation		Shielding around a 4 inch field of radiation	
	'Lap' (testicular area)	Ovarian area	'Lap' (testicular area)	Ovarian area
inches				
36	60	24	10	<2
33	76	29	16	4
30	99	—	19	—
28	125	44	31	10
26	143	—	40	—
24	166	60	40	10
22	195	—	53	—
20	>200	—	65	—
18	—	—	90	16
16	—	—	110	—
% of Gonad-Dose recorded in the 'lap' with an unrestricted field of radiation	100%	35–40% (37% Avg.)	17–28% (23% Avg.)	
% of the Gonad-Dose recorded in the 'lap' with a restricted field of radiation			100%	18–30% (25% Avg.)

3. Direct lead shielding of the gonadal area. Direct shielding of the gonadal area was accomplished by placing a lead shield 0.5 mm thick immediately anterior to the phantom, a procedure comparable to covering the lap of a seated patient to shield the pelvis and abdomen. Table IV shows that this technic reduced the gonad dose to an average of 15% of the dose recorded without shielding. The additional shielding of the periphery of the field of radiation, restricting it to 4 inches, reduced the dose still further, so that it averaged 2 to 3 per cent of the dose recorded without either of these two technics (Table IV).

4. Softer quality radiation. With the use of lower kilovoltage radiation (52 kv, 7 ma, HVL 0.6 mm Al) the gonad dose in the unshielded phantom averaged 47% of the dose recorded when 90 kv radiation with an HVL of 0.8 mm Al was used (Table IV). When in addition to the softer radiation the field of radiation was restricted to 4 inches, the gonad dose was reduced to an average of 10% of the dose recorded without shielding at 90 kv.

The Sources of the Radiation Constituting the Gonadal Area Dose in the 'Seated' Phantom

As the gonadal area of the 'seated' phantom is well outside the useful portion of the primary beam of x-rays, the radiation reaching this area can come either through the tube head or as scatter from the x-ray table or other objects in the primary beam. When the lap of the phantom is very close to the table, peripheral portions of the primary beam may irradiate the gonads. In order to ascertain what part each of these sources contributed to the gonad dose, a 0.5 mm sheet of lead was interposed between the source and the dosimeters; the standard therapeutic dose of radiation was then delivered and the resulting gonad dose recorded (Table V). In Position 1, a 1 x 2 foot lead shield (0.5 mm thick) was placed to interrupt any leakage from the tube head or any primary beam radiation that might reach the gonadal area directly. The shield extended down to the upholstered surface of the x-ray table. This technic reduced the gonad dose to an average of 68% of the dose recorded without

TABLE IV

Studies on the Phantom in a 'Seated' Position

Readings of the dosimeters placed in the 'lap'. Comparison of the Gonad-Dose with (1) an unshielded phantom and unrestricted field of radiation, (2) with a sandbag placed in the irradiated field, (3) with direct shielding of the gonadal area, (4) with low kilovoltage radiation, and finally, with restriction of the size of the irradiated field to a 4 inch square in combination with each of the above technics.

Horitontal Distance From the Axis of the X-Ray Beam to the Dosimeters in 'Lap'	Dosimeter Readings in mr per Exposure			
	Unshielded phantom (1)	Sandbag placed in the field of radiation (2)	Direct gonadal area shielding (3)	52 kv radiation (HVL 0.6 mm Al) (4)
Unrestricted field of radiation on x-ray table				
inches				
36	60	29	4	23
33	76	52	10	34
30	99	63	22	46
28	125	77	20	56
26	143	91	19	82
24	166	122	24	78
22	195	129	34	92
20	>200	173	40	106
18	>200	>200	56	114
% of unshielded Gonad-Dose with 90 kv radiation	100%	48–73% (62% Avg.)	7–21% (15% Avg.)	39–57% (47% Avg.)
Field of radiation restricted to a 4 inch square on the x-ray table				
36	10	10	<2	3
33	16	14	<2	6
30	19	15	<2	6
28	31	20	4	8
26	40	30	3	11
24	40	41	4	20
22	53	50	4	30
20	65	52	8	34
18	90	56	14	32
16	110	74	21	50
% of unshielded Gonad-Dose with an unrestricted field and 90 kv radiation	17–28% (23% Avg.)	15–25% (19% Avg.)	2–3% (2–3% Avg.)	5–16% (10% Avg.)

shielding.* The same shield was then moved down so that it extended down one foot from the surface of the padded table along the side adjacent to the chair (Position 2). This procedure reduced the scatter from the upper part of the table so that the resulting gonad dose averaged 27% of the unshielded dose. A lower extension of the same shield was then added to eliminate the scatter from the lower part of the table and and floor (Position 3). This made little difference in the amount of radiation reaching the gonadal area.

Finally, a special lead cone was devised that fitted closely around the opening in the tube head and extended to the table surface, (Position 4) limiting the field of radiation to an area 12

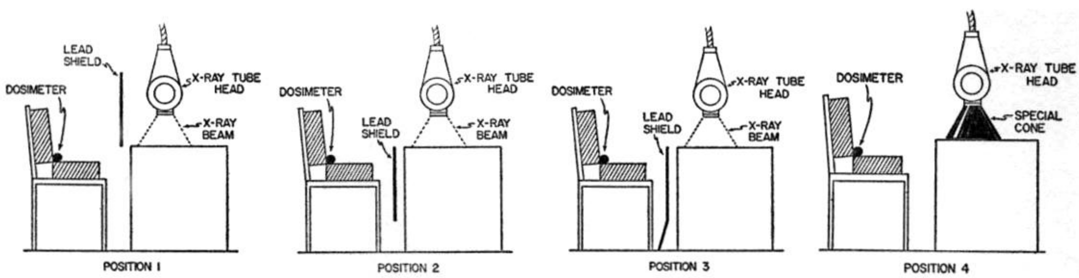
* It was inadvertently discovered during the course of more recent studies, using a metal x-ray table, that the extension of the shield in Position 1, Table V, to the metal table top (thus also shielding the edge of the 4 inch thick upholstered pad) reduced the gonad dose much further than when the shield extended only down to the upholstered surface.

TABLE V

Studies on the Phantom in a 'Seated' Position

Readings of the dosimeters placed in the 'lap' of the seated phantom. Comparison of the effects of lead shielding placed in various positions designed to reduce different components of the Gonad-Dose.

Distances From the Axis of the X-Ray Beam to Dosimeters in 'Lap' of Phantom	Dosimeter Readings in mr per Exposure				
	Unshielded	Shield in position 1	Shield in position 2	Shield in position 3	Special cone position 4
inches					
36	56	30	20	18	24
33	60	40	17	21	30
30	90	66	32	20	60
26	144	102	35	32	73
24	176	120	30	30	78
22	194	152	40	40	90
20	>200	>200	70	66	146
% of the Gonad-Dose in the unshielded phantom	100%	53–75% (68% Avg.)	21–35% (27% Avg.)	21–35% (25% Avg.)	44–66% (50% Avg.)



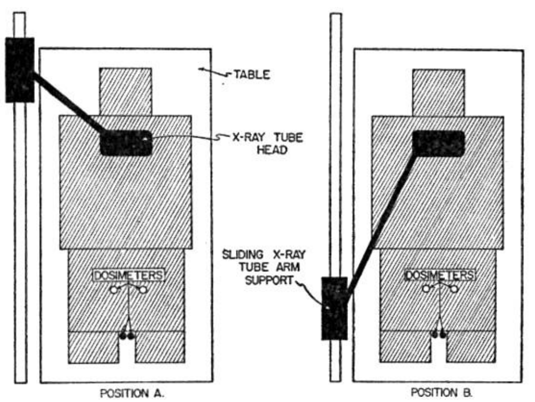


FIG. 3. Diagrammatic representation of two positions of the sliding metal arm supporting the x-ray tube head, that resulted in variations of the Gonad-Dose.

inches in diameter. This reduced the gonad dose by one-half.

During the course of these studies unexpected variations in the recordings of the gonad dose were discovered when the x-ray tube arm support

TABLE VI

Studies on the Phantom in a Horizontal Position

Readings of the dosimeters placed in the testicular and ovarian areas of the phantom. Comparison of two positions of the x-ray tube arm support. No shielding.

Distance from X-Ray Tube to Dosimeter	Dosimeter Readings in mr per Exposure	
	Position A	Position B
inches		
36	<2	<2
32	4	4
30	5	6
29	6	5
28	8	4
27	8	6
26	9	9
25	19	21
24	25	35
23	40	55
22	80	95
21.5	145	196
21	186	>200

was placed in the two different positions illustrated diagrammatically in Fig. 3. The differences in gonad dose are recorded in Table VI. It is possible that under these circumstances there is an increased scatter of radiation from the tube arm in Position B as compared to Position A. The source of the added amount of radiation recorded in Position B was not accurately determined.

DISCUSSION

The results of our previous studies (5–7) using these technics, demonstrated that the dosimeter readings recorded in the phantom corresponded quite closely with those recorded by dosimeters placed on the skin as close as feasible to the gonadal area of patients receiving as nearly as possible similar amounts of radiation under similar conditions. We feel that the information gained through the present studies on the phantom, in general can be satisfactorily applied to the treatment and the protection of patients. We say this despite our recognition of the fact that the use of the Keleket K-112 dosimeters as recording devices is not entirely satisfactory.* However, when the present studies were begun there was not, to our knowledge, a more accurate small recording instrument readily available for use in measuring radiation in the energy range of 50–90 kv peak.

The lead-rubber sheet wrapped as a girdle around the phantom in a horizontal position reduced the gonad dose from therapeutic radiation to the upper chest or back by 50%. This indicates that approximately half of the radiation reaching the gonadal area of the phantom under unshielded conditions apparently is from leakage and external scatter radiation, and that the other half is in part scatter from the primary beam, originating within the phantom itself. Our studies indicate that this dose can be further reduced by using therapeutic radiation of lower kilovoltage.

* Dosimeter readings in x-ray fields of effective energies less than 300 kv are affected by changes in the wavelength of the incident radiation, and the instruments tend to record somewhat high values for this region, down to about 50 kv. With various recordings of x-radiation in similar kilovolt ranges, however, the readings on these dosimeters are strictly comparable and are therefore entirely valid for measuring and comparing the differences in the gonad dose effected by different methods of shielding.

Based on the phantom studies, when patients are treated in a seated position in a chair adjacent to the x-ray table, the ovarian area in females may be expected to receive less than half the amount of radiation which will be received by the gonadal area of a male patient, providing the same dose and quality of radiation is administered. Reducing the size of the irradiated field, together with direct shielding of the gonadal areas, is an efficient technic for reducing the amount of ionizing radiation reaching the gonadal area of patients treated in the seated position. The addition of a sandbag in the field also serves to reduce the scatter radiation. As this is a commonly used device for supporting a treated extremity, it appears that it would be valuable to study the properties of various fillings other than sand, which might be used advantageously to further reduce scatter radiation.

The fact that the amount of scatter radiation reaching the gonadal area is markedly reduced by utilizing radiation of lower kilovoltage strengthens the present trend toward the use of softer radiation for the treatment of numerous dermatoses. There is little doubt but that the use of x-radiation of softer quality will retain essentially all of its therapeutic value (perhaps even add some) in the treatment of the majority of superficial dermatoses and greatly increase the safety with which it may be used.

Approximately three-fourths of the radiation comprising the gonad dose in a seated patient, under the conditions of this study, originates as scatter from the table and adjacent structures. The remaining one-fourth comes directly through the x-ray tube head as leakage, and/or from the peripheral portion of the primary beam.

The fact that the specially constructed lead cone, as used in these studies, reduced the gonadal area dose by approximately one-half in the seated phantom, indicates the advantage of having this type of attachment on all x-ray machines to be used under similar circumstances. It decreases the gonad dose by eliminating the peripheral or outer portions of the primary x-ray beam. It is these portions of the primary beam that appear to produce most of the scatter from the table as well as being the source of direct radiation to the gonads of patients seated close to the table.

Because the quality of scatter radiation varies with each x-ray apparatus and table and the materials used in its construction, it would be necessary to determine the characteristics of the scatter radiation for any given arrangement and type of x-ray set-up. Lindell (11) has studied in detail the nature of the scatter produced by low kilovoltage radiation from different materials, many of which are used in construction and shielding of x-ray rooms and apparatus. Determination of the HVL of the scatter radiation produced under the circumstances of these studies was not practical with the recording instruments used (see footnote page 244).

We feel that in general, the technics used in these studies for the purpose of reducing the gonad dose should prove both practical and valuable for the following reasons: (1) they utilize shielding materials and devices that are readily available, inexpensive, and easily handled; (2) the procedures are relatively speedy and simple, and cause no discomfort or undue alarm to the patient; (3) they are efficient in reducing the gonad dose to such a level that the concern now voiced over the possible genetic effects of therapeutic radiation, at least as given for most dermatologic disorders, may be greatly alleviated.

SUMMARY AND CONCLUSIONS

1. Measurements have been made of the amount of ionizing radiation reaching the "gonadal areas" of a pressed wood phantom (comparable to the Gonad Dose in patients receiving routine dermatologic x-ray therapy under various commonly encountered conditions).

2. The possible sources of the ionizing radiation comprising the gonad dose are discussed.

3. It is demonstrated that the gonad dose may be significantly reduced by the use of various shielding technics and other precautions.

4. A lead-rubber sheet 0.06 inches thick (1/16 inch) wrapped around the lower two-thirds of the phantom lying horizontally on the x-ray table reduces the gonad dose by approximately 50%.

5. Reduction of the size of the irradiated field, in combination with direct shielding of the gonadal area, is the most effective method of reducing the gonad dose in the seated phantom. The dose can be reduced 97%.

6. A lead cone devised to extend from the x-ray tube aperture to the surface being irradiated and to border the field to be irradiated reduces the gonad dose in the seated phantom by 50%.

7. The technics recommended for reducing the gonad dose are readily available, feasible for easy use, economical, and efficient.

REFERENCES

1. Stanford, R. W. and Vance, J.: The quantity of radiation received by the reproductive organs of patients during routine diagnostic x-ray examinations. Brit. J. Radiol., **28:** 266, 1955.
2. Clark, Stanley H.: Genetic radiation exposures in the field of medicine. Bull. Atom. Sci., **12:** 14, 1956.
3. Laughlin, John S. and Pullman, I.: The gonadal dose produced by the medical use of x-rays. A report prepared for the Genetics Committee of the National Academy of Sciences' study of the biological effects of atomic radiation. Preliminary Edition, 1957.
4. Callaway, J. L., Moseley, V. and Barefoot, S. W.: Effects of roentgen ray irradiation on the testes of rabbits: Possible harmful effects on human testes from low voltage roentgen ray therapy, Arch. Dermat. & Syph. **56:** 471, 1947.
5. Witten, Victor H., Sulzberger, Marion B. and Stewart, William D.: Studies on the quantity of radiation reaching the gonadal areas during dermatologic x-ray therapy. I. Preliminary report. J. Invest. Dermat., **28:** 187, 1957.
6. Sulzberger, Marion B., Stewart, William D. and Witten, Victor H.: A review of some factors in the quantity of radiation reaching the gonadal areas during dermatologic x-ray therapy. Dermatologica, **115:** 433, 1957.
7. Witten, Victor H., Sulzberger, Marion B. and Stewart, William D.: Studies on the quantity of radiation reaching the gonadal areas during dermatologic x-ray therapy. II. Methods, quantitative measurements, and analyses of some important factors influencing the gonad-dose, A.M.A. Arch. Dermat., **76:** 683, 1957.
8. Permissible dose from external sources of ionizing radiation. National Bureau of Standards Handbook 59, Supt. of Documents, Washington, D. C.
9. Recommendations of the International Commission on Radiological Protection. Brit. J. of Radiol. Supplement #6, 1954.
10. The biological effects of atomic radiation—Summary reports. Report of the Committee on Genetic Effects. National Academy of Sciences, Washington, D. C., 1956.
11. Lindell, Bo.: Secondary roentgen radiation. Acta radiol., **41:** 353, 1954.

DISCUSSION

Dr. Anthony N. Domonkos (New York, N. Y.): I congratulate Dr. Stewart and his colleagues on this wonderful piece of work. We do need this type of work because it has been said that dermatologists have no idea of how much radiation they are giving and their patients have no idea how much they are receiving. The idea of decreasing the amount of radiation to the gonads is mainly because of the genetic effects that may be produced in future generations of the patient receiving the radiation. Moreover, it is known that we cannot measure the amount of radiation that will cause mutation or genetic effects because even a small amount, one-half, one-quarter, one-eighth of a roentgen can produce as much damage as 100r to the gonadal area. This becomes very important in the way of protection or shielding because there are young children who are being treated by means of x-ray, mainly for x-ray epilation due to T. capitis and also for adolescents in acne vulgaris. In these occasions it is important that proper shielding be performed.

Dr. Andrews and I have been very much interested in this problem and our findings have been quite similar to what Dr. Stewart and his colleagues have found. We covered the entire table with lead rubber and then also covered the patient with lead rubber. In that manner the amount of radiation reaching the gonads was unmeasurable. It is very important that the tube housing be of a modern type of construction because there is leakage of radiation. It is a scatter type of radiation.

I would like to ask the presenters if they made any measurements as to the quality of radiation reaching the gonads.

The other point that should be very much emphasized is the use of cones in giving x-ray therapy. Today it is inexcusable not to use protective cones to minimize scattered radiation.

I enjoyed this paper very much.

Dr. George C. Andrews (New York, N. Y.): I enjoyed hearing this paper very much. Several points come up for discussion.

In the first place, we have no ideal ionization chamber for measuring this gonad dose and the Keleket Chamber and the Victoreen Chamber really do not measure the soft radiation that is back scatter from the floor and from the table and that may constitute the gonad dose. Nylon chambers or chambers made of polystyrene fiber are preferable. However, there is no one chamber that is ideal for this purpose.

The matter of the sitting position: I think a lot of that radiation with a large cone, such as shown in the picture, is probably the primary beam. That of course can be avoided by directing the primary beam away from the gonads. It is very important that the primary beam always be directed away from the gonads.

With Dr. Stewart, I agree when you have to irradiate near the gonads, soft qualities of radiation are better. We are interested in this gonad dose in people under 30 years of age. One half of the children are born to parents 30 years of age or under. The other half are born to people under 40. So in people over 40 it does not make much difference about the gonad dose. Those are the people we treat for skin cancer. When we treat younger people with acne of the face, we can irradiate the face without having the gonads get any measurable dose, not even a tenth of a milliroentgen. We must observe ordinary precautions of putting lead rubber sheet under the patient as well as over the patient. But the most important is under the patient because most of the gonad dose is a back scatter from the floor and from the walls of the room.

There are a couple of hopeful things I heard and that is that the rats on Eniwetok Island bombed out 38 times by hydrogen and atomic bombs are still there, still alive and still rats and we hear a lot of scary things in the newspapers about the dangers of sterility and shortness of life of radiologists but those studies on the shortness of life of radiologists are being revised and are inaccurate. Dr. Crowe at a recent meeting showed that if the average lifespan is 70 years, it might be shortened 20–35 days. The statistics on leukemia in children, from pelvimetry are open to question. The leukemia incidence in radiologists is not by any means settled. It has a lot to do with the geographical distribution, age groups, so forth. So there are a lot of things that we do not know much about but we all agree that the less radiation we give to the gonads the better.

The whole subject of the dangers of radiation has been distorted in much of the publicity.

Dr. Clarence S. Livingood (Detroit, Michigan): I just rise to ask the presenter one question, whether they have done any similar studies with grenz ray.

Dr. William D. Stewart (in closing): I would like to thank Dr. Domonkos, Dr. Andrews and Dr. Livingood for their comments.

Dr. Domonkos mentioned the gonad dose from x-ray for the treatment of T. capitis of children. In our studies on patients at the New York Skin and Cancer Clinic, using the Kienbock-Adamson technic, in epilation for T. capitis, the gonad doses received by children are really very small, and become negligible with the use of the protective lead rubber girdle. This is also true of the gonad dose received from most therapeutic dermatologic x-ray treatment to the face and the head area. The gonad dose under these circumstances is really quite small.

Our studies with the lead rubber lying on the surface of the table and then over the patient were mentioned. We found the most satisfactory protective method was to wrap the patient treated in a horizontal position, in a lead rubber girdle. This was the most effective and much the easiest technic under our circumstances of therapy.

I agree with the comments about the recording chambers. I think they are probably not adequate for obtaining the absolute values of the scatter radiation that we are now measuring. Studies are being done now to further evaluate the quality of this radiation. We have no good results yet.

We have done a few studies on the gonad dose from grenz ray therapy. These are only rough preliminary studies. While I would not like to make a definite statement, we find so far, through the range of patient positions that we have investigated, careful use of grenz ray offers no significant gonad dose measurable by our present methods.